

Colorado School of Mines  
Center for Welding Research

Quarterly Report

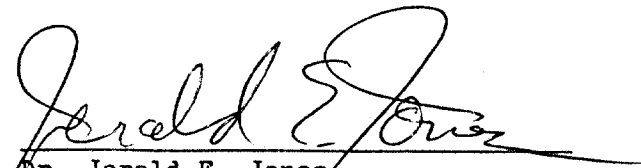
April 8, 1984 - July 8, 1984

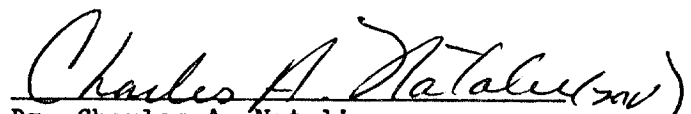
Use of Radioactive Tracers to Detect  
Stress-Corrosion Cracking in Offshore  
Pipeline and Structural Welds

Prepared for:

United States Department of Interior  
Offshore Minerals Management Service  
Reston, VA

Prepared by:

  
Dr. Jerald E. Jones  
Associate Professor  
Co-Principle Investigator

  
Dr. Charles A. Natalie  
Assistant Professor  
Co-Principle Investigator

July 18, 1984

To date, the primary efforts of this project have been devoted to the selection and fabrication of an appropriate welding consumable, an evaluation of commercially available detection technology for both radioactive and chemical tracers through a literature search, and development of methods to expand the usefulness of this non-destructive testing technology given the nature of stress-corrosion cracking in weldments.

#### Selection of a Weld Filler Metal

The weld filler metal chosen for this project is an 18Ni(250) maraging steel. It is a high-strength ferritic steel known to readily stress-corrosion crack in seawater and containing both of the elements currently being considered for this project in appreciable concentration (Cobalt - 8%, nickel - 18%). This material is available in wrought form as 0.5 in. dia. rod, but not as welding wire. Consequently, it was necessary to fabricate the welding consumable for this project. Complete hot-rolling and wire drawing facilities are available at the Colorado School of Mines and production of the welding consumable is in progress. However, some delay has been encountered due to the requirement to anneal the wire. The available furnace capacity at the CSM - Center for Welding Research was not sufficient, and a large annealing furnace has been constructed and is being used for this project.

#### Evaluation of Detection Technology

The methods in ASTM Standard D1890-81 are described as capable of accurately detecting and measuring Co-60 at concentrations as low as .01 parts-per-trillion from the intensity of its beta emissions. These methods are laboratory methods and portable detection systems appropriate for this technology will suffer a loss in sensitivity--potentially as much as two

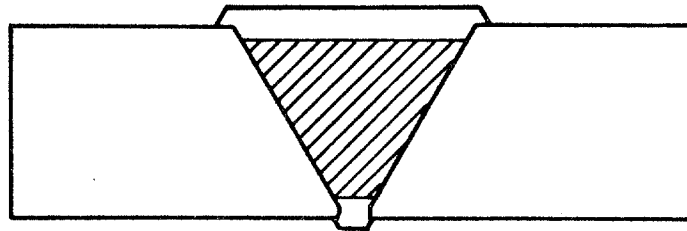
orders of magnitude. The resulting sensitivity of parts-per-trillion appears to be a quite adequate level of detection for this inspection method to be practical. Correspondence is currently in progress to determine the sensitivity and commercial availability of portable detection systems capable of measuring beta-radiation in an aqueous environment. Such a system would provide an ideal inspection capability for remote artificial intelligence inspection systems as well as for on-line monitoring.

#### Other Applications of This Technology

As can be seen in Figure 1, this technique appears quite applicable to stress corrosion or other cracking which occurs in the fusion zone of the weldment. Since stress-corrosion cracking associated with weldments frequently occurs in the heat-affected zone as well as in the base metal, any modification to this method that would allow it to be used to detect stress corrosion cracking in the heat-affected zone as well would greatly increase its effectiveness and usefulness. This may be accomplished by a process known as buttering in which a single layer of weld metal is deposited on the surfaces to be welded prior to welding as shown in Figure 2. In this case, the buttered layer would be applied prior to the heat treatment normally performed on the high strength pipe or structural steel and would contain the desired distribution of tracer material or minor alloying element to be transformed into radioactive tracer. Any annealing or normalizing heat treatment would cause the heat-affected zone from the buttering process to revert to approximately the same microstructure as the base plate--markedly reducing its susceptibility to stress-corrosion cracking. Upon fabrication welding, the heat-affected zone will form in the previously buttered material containing the desired distribution of tracer material. Thus, the technology

AS WELDED

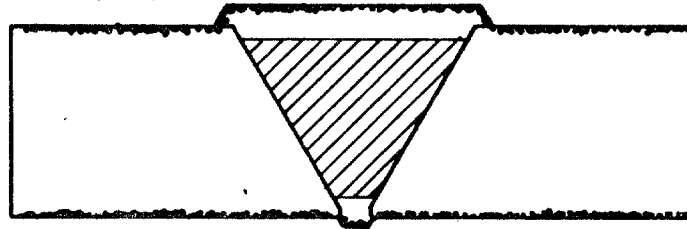
SHADED AREA CONTAINS TRACER



GENERAL AND SURFACE CORROSION

MECHANICAL INTEGRITY MAINTAINED

NO TRACER LEAKS INTO ENVIRONMENT



STRESS-CORROSION CRACKING

MECHANICAL INTEGRITY COMPROMISED

TRACER LEAKS INTO ENVIRONMENT

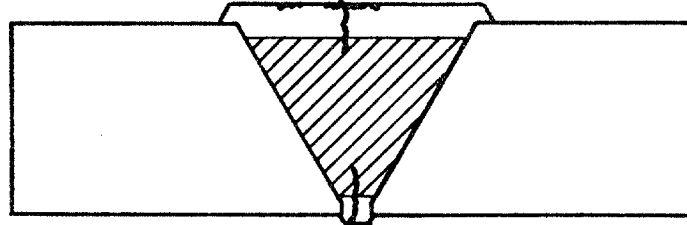
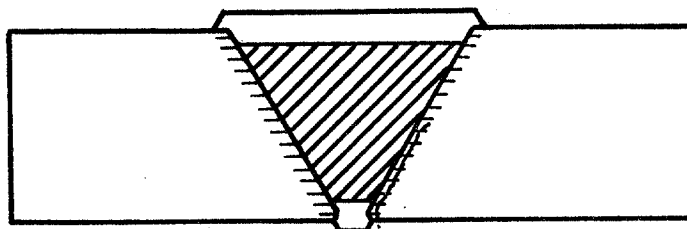
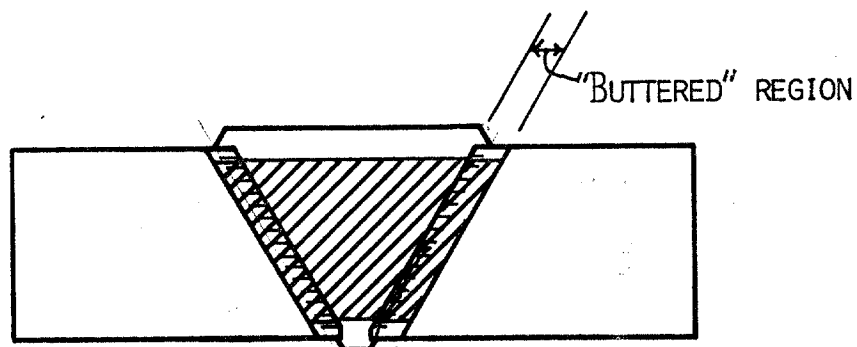


FIGURE 1: GENERAL CONCEPT OF NDE METHOD



TRACER CONTAINED IN WELD METAL ONLY  
STRESS-CORROSION CRACKING IN HAZ  
IS NOT DETECTED.



TRACER CONTAINED IN WELD AND HAZ ("BUTTERING")  
STRESS-CORROSION CRACKING IN HAZ  
IS DETECTED.

FIGURE 2: IMPROVEMENT OF TECHNIQUE THROUGH  
BUTTERING.

being evaluated in this project can be capable of detecting stress-corrosion cracking both in the weld metal and in the heat affected zone.

#### Experimental Program

The experimental program is progressing on time, except for the delay encountered in producing the welding consumables. The simulated sea water baths are in place and ready for use. The ultrasonic system is being tested to verify that the stress corrosion cracks can be located accurately, and crack growth monitored during the corrosion experiments.

It is estimated that welding and machining of the samples will be completed in late July or early August and crack monitoring will begin. Based on data from the literature regarding the expected stress corrosion cracking rate of material with the same composition as the selected welding consumable, chemical analysis of the corrosion baths will be performed approximately every 48 hours. At those times, an ultrasonic scan of the samples will be used to determine the crack extension. This data will be used to examine the extent of crack growth as a function of the concentration of tracer material in the sea water solution.

In addition to dissolution of tracer in the sea water, it is anticipated that any corrosion product which forms near the surface of the weld adjacent to the crack opening may contain tracer material. If sufficient corrosion product develops during the testing, that material will be collected and analyzed for tracer material content.